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Research Article

Applications of remote sensing and GIS for watershed characterization and soil loss assessment of tons watershed in Dehradun, Garhwal Himalaya

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ABSTRACT
Watershed characterization is the most important part of watershed management which includes soil loss, soil loss assessment indicates the amount of soil loss or erosion in ton/hectare/ year through applying to Geospatial techniques as Remote sensing and GIS. The agricultural land is being lost by manmade as well natural whereas manmade or anthropogenic factor accelerates erosion of soil. It is a worldwide phenomenon leading to loss of decrease of water table availability for plants, increases runoff from the more impermeable subsoil, and loss of nutrients from the soil. Watershed management and assessment of soil loss are most helpful for planning and batter management in a watershed and planning units. Remote sensing and GIS along with the satellite image-based model approach provides a scientific, quantitative, and applied result. It can compute a consistent outcome of soil erosion and sediment yield for a wide range of areas under all climatic circumstances. Revised Universal Soil Loss Equation (RUSLE) apply to soil loss, which is integrated with Remote Sensing and GIS in Tons watershed lies between 77°56'05" E to 78°01'01" East longitude and 30° 21'05" N to 30°26'51" North latitude, having 97.02 km2 area (9,702 hectares) under the sub-tropical climatic region of Uttarakhand. The present case study based on computational with software and geospatial technologies results come i.e. A = is the computed soil loss per unit area, R = is the rainfall erosivity, K = is the soil erodibility factor, L = is the slope-length factor, C = is the cover and management factor, P = is the support practice factor. The rainfall erosivity ($R=87.5 + 0.375 \times R$), C P is under range 0.006-0.8, Soil Erosion Risk range is slight to High 51.40% and 0.85% total area of the study region. Average annual soil loss ton/ha/year indicated in different land-use classification as lowest soil loss found in River bed (0.17 ton/ha/year) and highest shown in the open forest (56.58 ton/ha/year) in 2016. The study area comes under a low probability zone and partially comes under a moderate and moderate-high zone. The case study can be highly recommended and will help to implementation of management of soil loss and soil conservation practice in the Tons watershed as well as Himalayan regions.
Keywords: *RUSLE, Tons Watershed, Soil Loss, Remote Sensing & GIS, Garhwal Himalaya.*

INTRODUCTION

Soil is a natural form of mineral and organic components, which is different from the elements towards interior depth of soil in morphology, physical elements, chemical elements, structure and biological features. (Jofie, 1936 & Birkeland, 1974, 1999). Natural geological erosion process is the erosion of land and its natural state, even not by anthropogenic activities (Desmet and G. Govers, 1996). Uneven land surfaces are being continually eroded by running water, wind, ice or other geological agents. The eroded materials are then deposited in valleys and alluvial plains. The removal and formation of soil go on simultaneously. The process of soil formation is slow, but that of erosion may vary in its rate and magnitude. However, nature has a balancing between the two. The soil is the most important basic natural resources available for man. It serves as an anchorage for the plants and reservoir for the plant nutrients. The soils are responsible for the agriculture and forestry. It is, therefore, inevitable to use soils systematically to help and upgrade the standard of mankind (Soil and Water Conservation Society, 1993). Present days here has been a rapidly developing role which soil serves as one of the important primary resources.

A thorough knowledge of the soils finds a suitable place in planning for agriculture, forestry and other developments programme. The scientific information about soils is obtained through standard soil survey. Soil survey is an integral part of an effective agricultural research and advisory programme. Much attention and priority is being given for modernization of soil survey methods. Soil erosion over the earth surface is a quite-frequent and well-distributed troubled. Risk level area map is generated to important issue causing of water or wind, Soil erosion model especially indicate and draw attention

to soil coverage by lively green vegetation and residue (Berk Ustun, 2008).

When soil is covered with plants and crops residues, soil erosion is often reduced during heavy rainfall. (N Doidato, 2004). The farmer can play an important role to minimizing soil loss and conserve their agricultural farm himself. After all, it is the farmers who must reduce the level of erosion sediment from their cropland. Soil erosion from runoff by water is often accepted as an inevitable phenomenon that includes agriculture practices on sloping lands (Shown, Frickel *et al.,* 1981 & Gary C, *et al.,*, 1914). The loss by erosion or runoff is not an inescapable practice. The farmer can effectively control erosion, reduce runoff and increase the amount of water on his land through the use of site specific and customized farming systems and management practices. Runoff water is not known to be used for crops, while irrigation and blocked water can be used effectively by plants, which is very important for growing in dry climates. (W.H. Wischmeier and DD Smith, 1965 & 1978).

Soil erosion in agriculture systems is a very important problem to manage. Humus is constituent dirt and biotic components which is called topsoil. If this layer is eroded away by wind and water, then the ground is very unproductive in producing crops. High wind can blow away loose soils from flat or hilly terrain. Water erosion only occurs on slopes and its severity of the slope. In many parts of the world much of the wind erosion occurs in winter when the ground is frozen but the upper most layer of the soil is loose and dry. Water erosion occurs during the spring with the thawing and melting action of the snow. Several terms are used in association with the removal of soil from the land surface. Although there is not complete agreement in the connotations attributed to these terms, the following definitions are employed in this report. Erosion includes a group of processes by which earth materials are entrained and transported across a given surface. Soil loss is that material actually removed from the particular hill slope or hill slope segment (SK Saha, *et al.,*1992). The soil loss may be less than erosion due to on-site deposition in micro-topographic depressions on the hill slope. RUSLE estimates soil loss from a hill slope caused by raindrop impact and overland flow (collectively referred to as "in Terrill" erosion), plus rill erosion (C.C. Truman and J.M. Bradford, 1995). It does not estimate gully or stream-channel erosion.

MATERIALS AND METHODS

The case study has done through primary and secondary data integrated with Remote Sensing and GIS computation, other geospatial technologies, RS-GIS software, SOI Topo map for validation of the study area. All computational algorithmic analysis has been done in IIRS Lab Dehradun. LISS-III Satellite images, Soil data, Rainfall Data etc. collected from secondary sources. Primary data has collected for validation and analysed i.e. soil sample, physiographic survey, agricultural plots visit etc.

Satellite Data Used: Remote Sensing Data; Satellite-IRS-P6, Sensor-LISS-III

LISS-III image	DATE	PATH NO.	ROW NO.
1	15-March,2016	096	049

Software Used
ERDAS Imagine 10.0

ERDAS IMAGINE is a very useful programme for accessing a huge database of geospatial data. It enables us to make decisions on different situations. EEDAS Imagine can capture and tracks specific times and places, and monitor occurred changes. The programme is one of the best solutions, providing tools to create, manage and analyse imagery. It will provide us with high value geospatial information. The programme combines Remote Sensing and GIS techniques, which enable us to manage geospatial data, and extract information that we need.

Arc GIS 10.0

Arc GIS is a Geographic Information System (GIS) for working with maps and geographic information. Software is applied to creating maps, compiling spatial and non-spatial data, to sharing and discovering data, analysing and using maps even spatial and non-spatial information application, DBMS. GIS provides a basic framework for making maps and geographic information available on a web, and even without the web.

ILWIS Version 3.3

The Integrated Land and Water Information System is a PC based GIS, and Remote Sensing Software, developed by ITC up to release 3.3 in 2005.ILWIS comprise a complete package of image processing, spatial analysis and digital mapping. It is easy to learn and use. Also it has full online help, extensive tutorials for the direct use in the courses and 25 case studies of various disciplines

Soil Erosion Risk Assessment Using RUSLE Model

Soil loss is defined as the amount of soil eroded over a given time period in which pure soil loss is experienced. It is expressed in terms of mass per tonne, per hectare and per year (ton / ha / year). (Ton/ha/year) (Kuldeep Pareta & Upasana Pareta, 2012). USLE (Universal Soil Loss Equation) was introduced by Wishmeier and Smith in 1965 after revised this equation called RUSLE and modified as MUSLE version (Wishmeier and Smith, et. al., 1978), present study is based on RUSLE (Revised Universal Soil Loss Equation) to predict annual soil loss from study area. The RUSLE can be expressed as follows:

$$A = R \times K \times L \times S \times C \times P$$

Where,
A = Computed soil loss per unit area.
R = Rainfall erosivity.

K = Soil erodibility factor.
L = Slope-length factor.
C = cover and management factor.
P = support practice factor (assumed to be one)
Rainfall Erosivity (R)

The rainfall erosivity factor is calculated with the help of average annual rainfall of the seven years. The equation of calculating the rainfall erosivity is –

R= 1686+0.329*DEM

R Factor = 87.5 + 0.375 * R (Ram Babu equation for soil Rainfall erosivity)

Soil Erodibility (K)

K represents both susceptibility of soils erosion and the rate of runoff as measured under the standard unit plot conditions. The properties of a soil that influences its erodibility are soil texture, organic matter content and soil permeability (M.P. Tripathi, Panda, S R.K,Pradhan And S Sudhakar, 2002). Based on soil profile study and laboratory analysis, K values for various physiographic soil units were obtained and soil erodibility K factor map is generated.

Slope Length (L)

L factor is representing the effect of slope length on erosion. The length of the slope is the distance from the origin of the flow of land along its flow path to the place of deposition. In this case study LISS-III data by the help of ILWIS software utility button field width across the slope which represents slope length was measured. Homogeneous field areas were delineated and slope length measured of many fields and length was generated (S.K Saha. M Kudrat and SK Bhan, 1990).

Slope Steepness (S)

S factor represents effect of slope steepness on erosion, soil loss increase more rapidly with slope length. The relation of soil loss to gradient is influenced by density of vegetation cover and soil particle size (Dutta. Pradip, 1999). In this case study from CARTOSAT data DEM map was generated from which terrain slope map in percentage was generated.

LS factor is generated from the CARTOSAT DEM with the help of this equation:

LS=pow((flowaccumulation*30/22.1),0.14)* pow (Sin(Slope_rad)/0.09,0.6)

Crop Cover Management and Support Practices (C and P)

The C factor (Crop Cover Management) is used to represent the effect of cropping and management practices in a unit area which associate to erosion rates. This crop cover management is the most frequently used factor for comparing soil erosion effects, which will affect soil conservation planning, average annual soil loss, and that various activities such as crop rotation or other management plans are also included (B Bhusan, K.L Khera. Rajkumar, 2002).

Table 1: Areal extent of Physiographic Units

Physiographic Unit	PH Unit	Area (Sq. Km)	Area (%)
River Bed	R	1.41	1.64
Steep Himalayas Dense Forest	H11	3.44	4.02
Steep Himalayas Open Forest	H12	33.87	39.48
Moderate Sloping open Forest	H22	0.98	1.14
Settlement	S	4.99	2.79
Lower Piedmont (Scrub)	P24	9.73	1.34
Lower Piedmont (Fellow Land)	P25	1.97	2.29
Lower Piedmont (Agriculture)	P23	0.22	0.26
Residual Hill (Dense Forest)	RH1	5.94	6.92
Upper Piedmont (Dense Forest)	P11	1.82	2.12
Upper Piedmont (Scrub)	P14	11.98	13.97
Upper Piedmont (Agriculture)	P13	3.34	3.89
Moderate Sloping (Dense Forest)	H21	15.95	18.59
Moderate Sloping (Agriculture)	H23	0.30	0.35
Steep Sloping (Agriculture)	H13	1.01	1.18
Total		96.97	100.00

Support Practices (P)

P factor (Support Practice) represents the impact of support practices on the average annual erosion rate in ton/ha/year. In this study based on visual interpretation on FCC and field survey showing different management practices were interpreted and delineated. The polygon map was prepared and rasterized and finally the management practice values were assigned based on literature to generate attribute class map showing P value in the area and ultimately P factor map was generated. Different types of maps like LULC map, Physiographic map, slope map and soil map have been prepared by using satellite images and Topo sheet of the study area. Soil mapping needs identification of a number of elements (S.K. Bhattacharya, 2000). The elements which are of major importance for soil survey and land type, drainage pattern and drainage condition, vegetation, land use, slope and relief. The methodology comprises three round approach (Fig. 1);

Study Area

The study area is located in Dehradun district of Uttaranchal. The Tons Watershed is located between

$30^{o}19'51.26''$ to $30^{o}27'57.03$ N latitude and $77^{o}53'21''$ to $78^{o}02'56''$ E longitude. The area of the watershed is 129.4 km^2.Tons Watershed a part of Dehradun district, Uttarakhand state, India, lies between 77°56'05"E to 78°01'01" East longitude and 30° 21'05"N to 30°26'51"North latitude approximately, covering an area of 97.02 km^2 (9702 hectares). It is a part of Dehradun district, Uttarakhand state, India. The study area is situated in between towards Tons river in the south west, Forest Research Institute and Tapakeshwar, Badshahibagh agricultural area in the east, Bakarna reserved forest in the North East, Batoli Block Sal forest in the North West and Donga Block dense Sal forest in the west. The climate of the area is sub-tropical with mild to hot summer and very cold winter. The annual rainfall of the area is 2051.4 mm. The main landscape viz. mountain and piedmont constitute the area (Fig. 2&3).

There are no alluvial plains in our study area. The northern and north western regions are dominated by mountains; Southern and eastern parts are dominated by piedmont plains, along Darer, Ghulatia and Nimi rivers. The major land uses of the area are cultivation, forest and settlement. It is bound in the north by the Lesser Himalayan range and in the south by the Siwaliks. It forms an asymmetrical synclinal valley. This watershed is occupied by the Asan river which flows north-westwards and joins the Yamuna river. All these physiographic units are extended NW-SE to ENE-WSW. The major drainage present in the area is parallel to sub-parallel, sub-dendritic, trellis, angular, rectangular, intermittent and braided (Fig. 2).

RESULTS AND DISCUSSION

Physiographic Characteristics

In the physiographic map, physiographic units are divided into sixteen parts. These units are divided on the basis of slope steepness. The watershed falls under the hills and river terraces. Each unit has its own characteristics on the basis of soil, vegetation, and slope. The total area of the physiographic unit is 97.02sq. km and each unit have a different area. In physiographic map different soil attributes are examined like as; Soil depth, Texture, Drainage, Slope, Coarse fragment, and Erosion (SK Saha et al., 1992). The texture of the watershed varies from one map unit to another such as; the textures of the Hills are coarse sandy loam and silt loam. River terraces are silt loam and loam. The soil depth in the upper hills is extremely shallow to very shallow. In agriculture field, it is moderately deep, deep, and very deep. In the agriculture field, the coarse fragment is very slight and in upper hills, the coarse fragment is very severe (SK Saha et al., 1992).In watershed drainage are excessive and well due to slope steepness moreover, erosion is very high in the hills where land cover is very less, moderate in the upper river terraces, and slight in the agricultural fields (Table 2 & 3).

Table 2: Soil Characteristics of Various Physiographic-Soil Units

Physiographic Units	Slope (%)	Drainage	Coarse fragments (%)	Texture	erosion
H1	15-25	Excessive	40-75	Sl	e1/e2
H2	15-25	Excessive	40-75	Sl	e2/e3
H3	60-70	Excessive	40-75	Sl	e2
UP1	10-15	well	15-40	Sil	e1
UP2	7-10	Excessive	15-40	Sl	e2/e3
UP3	5-7	Moderate well	<15	L	e1
MP1	5-8	well	<15	Sil	e2
MP2	1-2	well	<15	Sil	e1
MP3	2-3	well	<15	Sil	e1
MP4	5-8	well	<15	L	e1
LP1	5-8	well	<15	Sil	E2/e3
LP2	3-5	well	<15	Sil	e1
LP3	1-2	well	<15	Sil	e1
RH	7-10	well	<15	Sil	e1
RT	1-2	Well	<15	sl	e1
River	-	-	-	-	-

Land use Land Cover

The major land use land cover of the study area is forest, agriculture, scrub land, and riverbed. The forest comprises dense forest, degraded forest. The scrub comprises dense scrub and open scrub. In agricultural field terrace and bonding practices are prominent (Table 3 & Fig. 5).

Rainfall Erosivity Factor (R)

It is calculated the average rainfall of the twenty-five years. The average rainfall of the twenty-five year is 2051.4mm. The equation is calculated the rainfall erosivity;

R= 1686+0.329*DEM (cell size of raster image)

R_Factor = 87.5 + 0.375 * R (Ram Babu equation for Rainfall erosivity)

Rainfall erosivity computed by Ram Babu (1978) which is specially favourable for Indian region. In study region, results observed rainfall erosivity range value varies *R*-value from 791.801 to 988.831 (Fig. 8). Rainfall intensity and slope are co-related for soil loss although duration of rainfall is most significance to erosion of soil (KG Renard, and JR Freimund, 1994). Runoff from agricultural lands are usually higher spring month when the soils are saturated, according to observed range of value is moderate and partial patches are under high erosivity of rainfall in the study area. Maximum area of the study region is under the moderate R factor, whereas intensity of rainfall not high which of area is under range of low and moderate.

Soil Erodibility (K) Factor

The K factor is an expression of the inherent erodibility of the soil or surface material at a particular site under standard experimental conditions (JK Mitchell *et al.,* 1983) The value of *K* is a function of the particle-size distribution, organic-matter content, structure, and permeability of the soil or surface material (J.V. Bonta and W.R. Hamon, 1980). For undisturbed soils, values of *K* are often available from soil surveys conducted by the National Resource Conservation Service (NRCS) for disturbed soils, the Nomograph equations embedded within the RUSLE program are used to compute appropriate erodibility values (W.R. Curtis and Superfesky, 1977). Soil texture is the major factor to affecting *K* factor, but structure, organic matter, permeability also contributes. Soil erodibility is computed from map of soil properties. There are thirty soil sample were collected from the field (Table 2).

Table 3: Areal extent of Land Use Land Cover

LULC Classes	Area(Sq. Km)	Area (%)
Settlement	5.152790106	5.310783
Dense Forest	19.14404139	19.73103
Open Scrub	1.312710808	1.352961
River Bed	1.411090578	1.454357
Fellow Land	1.968439706	2.028795
Dense Scrub	21.72384443	22.38993
Agriculture	4.858516631	5.007487
Open Forest	41.45361252	42.72465
Total	97.02504616	100

Table 4: Distribution of Slope in Study Area

Slope (%)	Area(h)	Area (%)
<2	463.35	3.668
2-8	3536.79	27.999
8-15	2773.48	21.956
15-30	3329.53	26.358
30-50	1757.99	13.917
50-70	454.67	3.599
>70	315.92	2.501
Total	12631.7	100

Table 5: C and P factor

UNIT	C Factor	P Factor
Orchards	0.05	0.5
Forest	0.006	0.5
Fallow	-	-
Scrub	0.05	0.5
Settlement	-	-
Riverbed	-	-
Agriculture	0.5	0.8

Table 6: Extent of Soil Erosion Risk Class in Tons Watershed

Classes	Soil Loss (t/ha/yr)	Area (Sq. Km)	Area (%)
Slight	0-10	49.7439	51.40
Moderate	10-25	4.7151	4.87
Moderate High	25-50	14.9643	15.46
High	50-100	26.5356	27.42
Very High	100-200	0.819	0.85
Total		96.7779	100.00

Table 7: Average Soil Loss in Study Area (2016)

LULC	Average Soil Loss (t/ha/yr)
Settlement	1.99
Dense Forest	0.49
Open Scrub	27.37
River Bed	0.17
Fellow Land	19.53
Scrub	2.18
Agriculture	18.88
Open Forest	56.58

The result of the physical and chemical analysis of soil samples was used for soil erodibility value ranges in value from 0.01 to 0.065 in the study area (Fig. 9). The *K* factor indicates with a numerical value from 0-1value Few patches are affected by high soil erodibility shown as red colour that represents closer to 0 value is negligible soil erosion or less prone moreover the value closer to 1 is high erosion or high prone (Fig. 9).

Flow Accumulation

The Flow direction operates that natural drainage direction for every pixel in the Digital Elevation Model (DEM). Output Flow direction map shows, after the Flow accumulation operation counts the total number of pixels that will drain into outlets point (Dissmeyer and Foster, 1980) (Fig. 10).

Drainage Density and Stream Frequency

Drainage density (expressed in terms of km/sq.km) indicates the total length of all streams and rivers in a basin divided by the total area of the drainage area which is more water will infiltrate. Fig. 10 and 11 shows the Stream order and flow accumulation map which is categorized into five stream order. Number of streams in one sq. km drainage density, higher would be runoff. Thus, the drainage density characterizes the runoff in the area or in other words, the quantum of rainwater that could have infiltrated. The drainage density in the area has been calculated after the digitization of the drainage pattern of the entire area, so the highest groundwater recharge probability is when the drainage density is low. Stream frequency is the total number of streams in an area indicating how many orders, how many streams and what patterns exist in a given area. Lower stream frequency recharges more groundwater. Hence medium (5 - 10 number stream), high (10) in a square km grid or area. 20 number of flows in one sq km enrichment) and very high (> 20 numbers of flow in one sq km enrichment) is considered correct. (Fig 11).

Topographic Factor (LS)

Topographic factor is constituting by slope steepness *(S)* and slope length *(L)* which are associated with accelerate rate of soil erosion. Steeper slope relates to increase the erosion whereas length of slope defined as distance of slope with slow creeping of soil towards down slope (Desmet and Govers, 1996). LS factor indicates the influence of LS on erosion process. Topographic factor computed by the flow accumulation and percentage of slope with RS computation. The nastiest erosion phenomena happen under range of slope in percentage between 10 to 25. Topographic factor is computed using by following equation;

$$LS = [(Qa\ M)/22.13]^{y} \times (0.65 + 0.045 \times S_g + 0.0065 \times S_g^{2}) \quad (4)$$

Where

LS = Topographical Factor;

Q_a= Flow Accumulation grid

S_g = Grid slope in percentage

M = Grid size (X x Y),

y = dimensionless value of 0.2-0.5

The result observed after computation in the study area about the LS factor is range 0.00917-59.1787 shown on map Fig. 12. The value of the topographic factor escalation as the flow accumulation and slope increases in the study area.

Crop Cover and Management Factor *(CP)*

Crop cover and management factor *(CP)* indicates land utilisations practices i.e., cropping pattern, settlement, Dense Forest, Open Scrub, River Bed, Fellow Land, Dense Scrub, Agricultural land and Open Forest, there are eight classifications in the study area maximum area covered by dense forest and open scrub with 42.72% and 22.38% respectively (Table 3 and Fig. 5). The *CP* factor has computed by the LULC map and prepared map (Fig. 13 & 14). The *CP* factor value varies 0 to 1 denotes near to 0 value represents erosion or soil loss is less and near 1 value shows more erosion.

In the study region has been observed *CP* value in each land use land cover classes viz. Orchards 0.05 & 0.5, Forest 0.006 & 0.5, Scrub 0.05& 0.5 and Agriculture 0.5& 0.8 respectively *C&P* value indicated separately. Fallow land, Settlement and River bed have no value (Table 5). Only one agriculture class observed *P* factor comprise value 0.8, it is closer to 1 i.e., soil erosion occurs is moderate near to high. Moreover, CP value in remaining the LULC classes under value 0.5 accepting agricultural land which indicates less erosion or a negligible amount of soil loss.

Soil Erosion Risk

After deriving all parameters of the RUSLE soil erosion risk map have generated. The extent of soil erosion risk class in Tons watershed can be seen in the soil risk map and the extent of soil risk class wise percentage shown in the table (JE Gilley et al., 1977). The formula to generate the soil erosion risk is given here as A=R × K × L × S × C × P. In the watershed 0.85 % under very high erosion, 27.42 % under high erosion, 15.46 % under moderate-high erosion, 4.87 % under moderate erosion and 51.47 % under slight erosion class. Soil erosion risk assessment has been categorised in five indexes as Slight 1-10, moderate 10-25, moderate-high 25-50, high 50-100 and very high 100-200 especially propounded for the study area. In the study area, soil erosion risk assessed by t/h/y under five index values observed as 49.7439 h under slight, 4.7151h under moderate, 14.9643 h under moderate-high and 26.5356 h area under the high and 0.819 h area under soil erosion risk-prone (Table 5 & Fig. 15). After the computation RKLSCP as RUSLE in remote sensing and GIS platform, results found average soil loss in each class of LULC in ton/ha/yr as Settlement 1.99, Dense Forest 0.49, Open Scrub 27.37, River Bed 0.17, Fellow Land 19.53, Scrub 2.18, Agriculture 18.88 and Open Forest 56.58 (Table 7, Fig. 15 & 16).

The study area was undertaken in a part of Dehradun district Uttarakhand with aim to assess the soil erosion risk in the Tons watershed using Remote sensing and GIS techniques. Assessment of soil erosion has been done with the help of Remote Sensing and GIS using RUSLE model. GIS incorporation with Remote Sensing is a peaceful technique for modeling soil erosion because major input parameters to the model can be derived from Remote Sensing data and the modelling part can be easily done in the GIS environment. The finding of the study; Average annual soil loss of the Tons watershed is 63 ton/ha/year. It is clear from the analysis of soil erosion in Tons watershed that the major cause of soil erosion is slope, heavy rainfall and deforestation to some extent. Highest soil loss from scrubland, current fallow, barren land, and low intensity of cultivation. Lowest soil loss from the dense forest. Most of the area is dominated by dense forest. For barren land has suggested restoration of vegetation cover especially by tree planting. The RUSLE model allowed describing the process of erosion and hence, the conservation method can be done within separate phases of erosion process. As a result of the study, the following conservation measures are suggested for scrubland, agriculture, and barren land in high and very high priority classes. The study permitted and recommended to the conservation of soil loss and soil erosion in the Himalayan regions.

RS and GIS help users to identify the soil erosion affected areas in Tons watershed. The observation and findings will help to conservation of soil loss and management of severe patches in Tons watershed. The outcomes will assist in the preparation of hazard zonation and disaster natural disaster management planning for a better manner. Tons watershed under the hilly region, because it often occurs natural events viz., cloud burst, flash flood, heavy rainfall, landslide, etc. therefore this paper will helpful for better management in Tons watershed. Remote Sensing and GIS is the most efficient tool to calculate and computation such as massive and complicated data rather than using empirical methods. Advanced techniques refer to getting reliable results and outcomes along with must be recommended validation with primary data and ground-truthing simultaneously.

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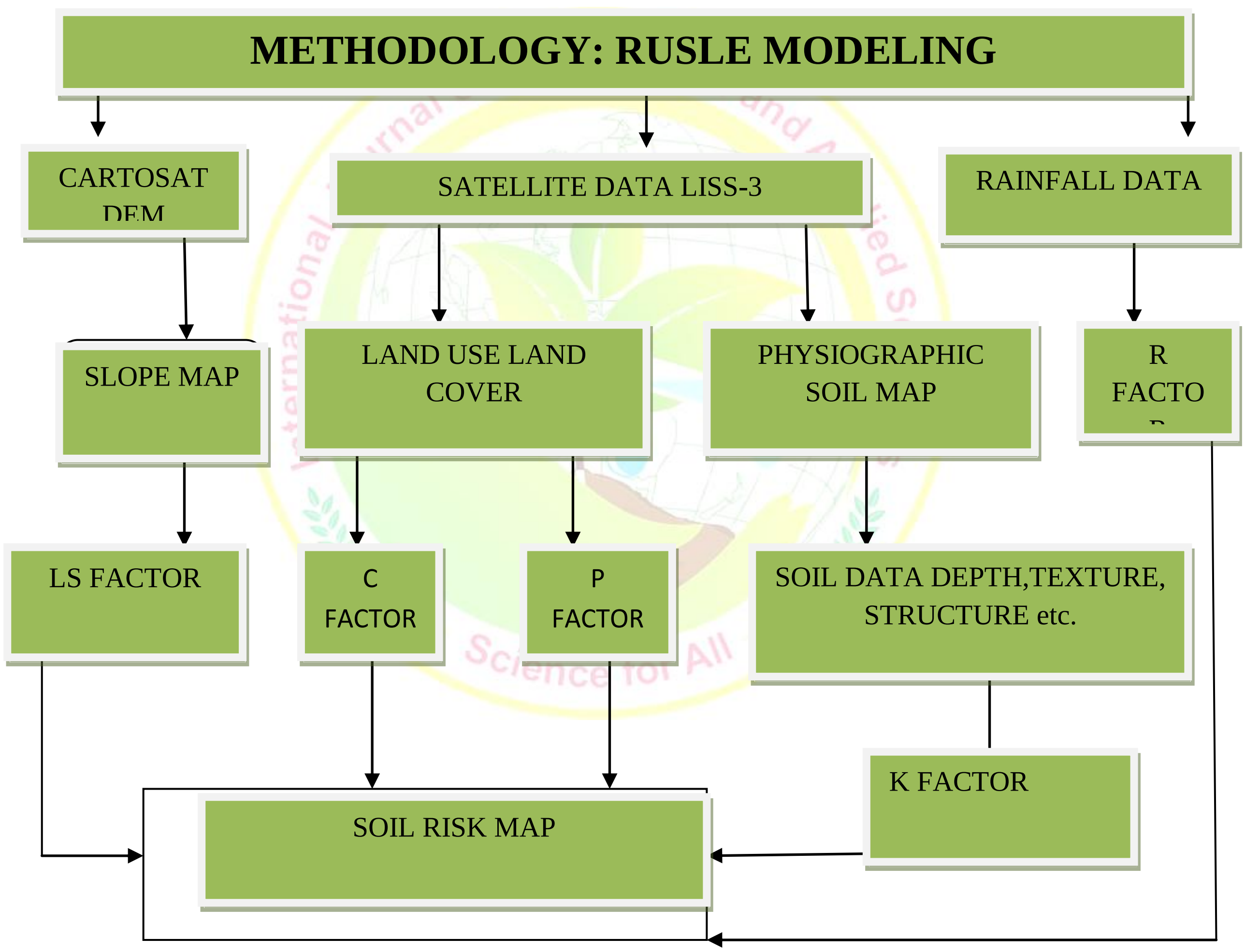
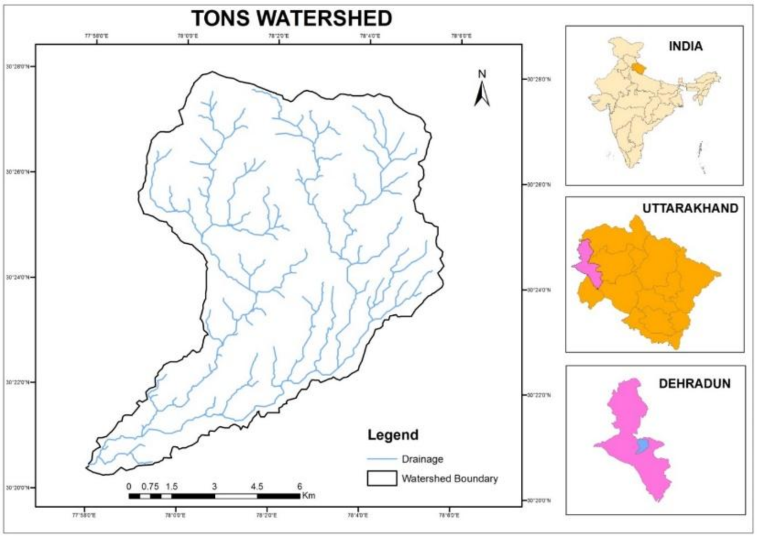


Fig. 1: Methodology



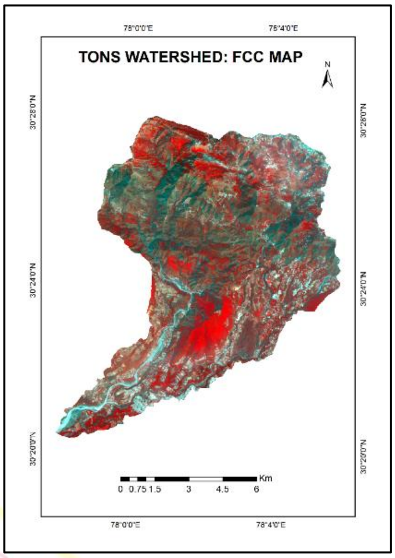
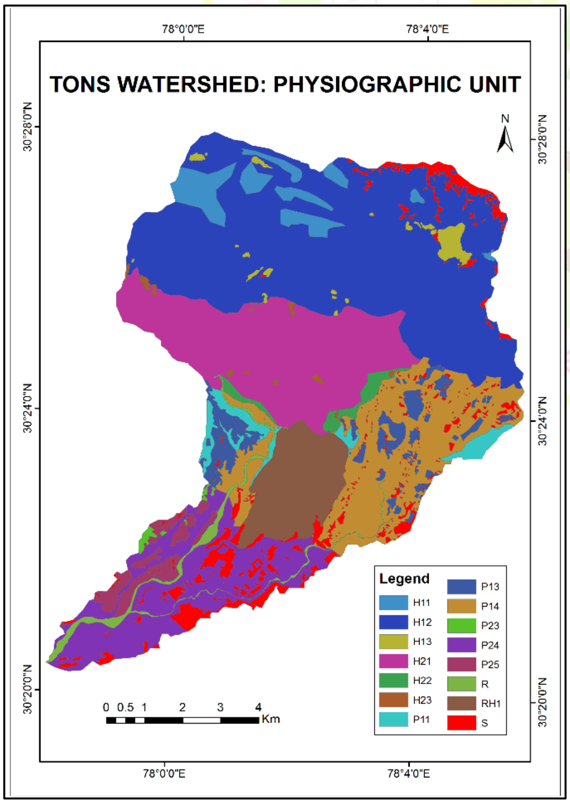


Fig. 2: Study Area, Tons Watershed **Fig. 3: FCC Map of the Study Area**



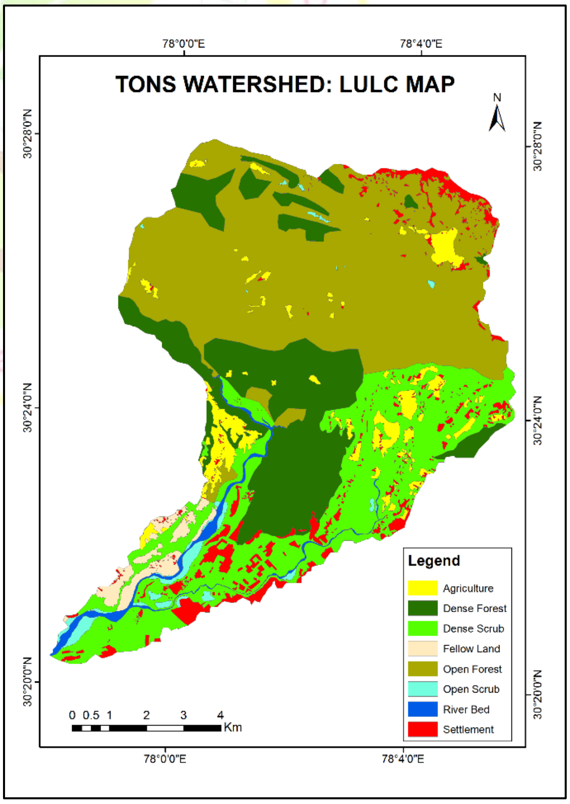


Fig. 4: Physiographic Units **Fig.5: LULC**

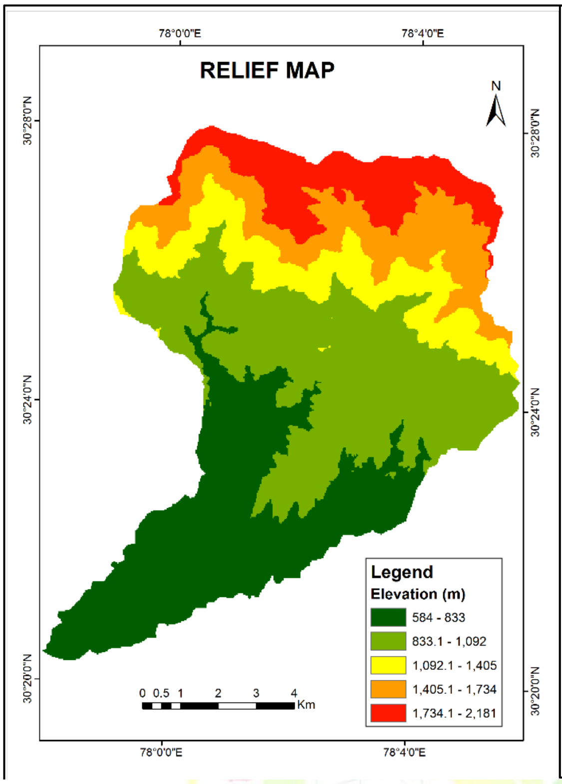


Fig. 6: Relief

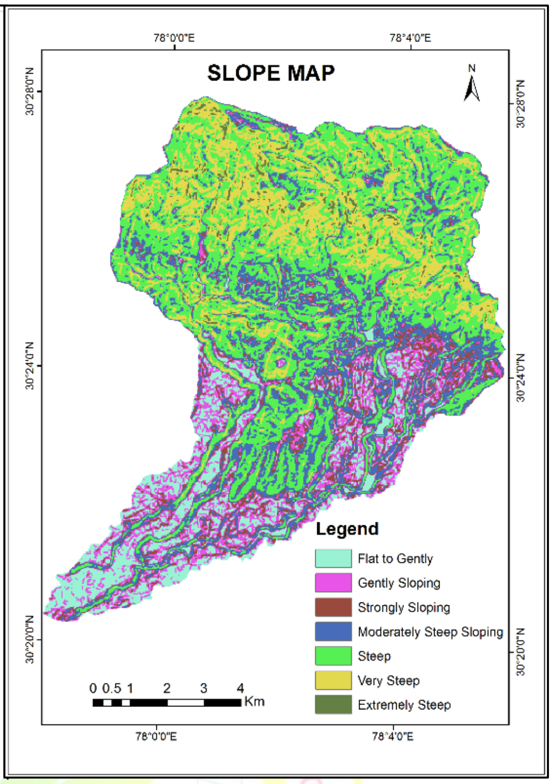


Fig. 7: Slope

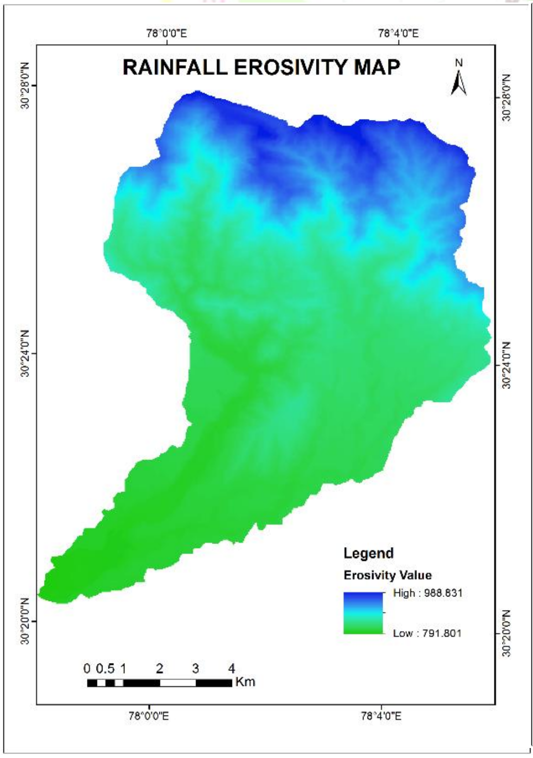


Fig. 8: Rainfall Erosivity (R)

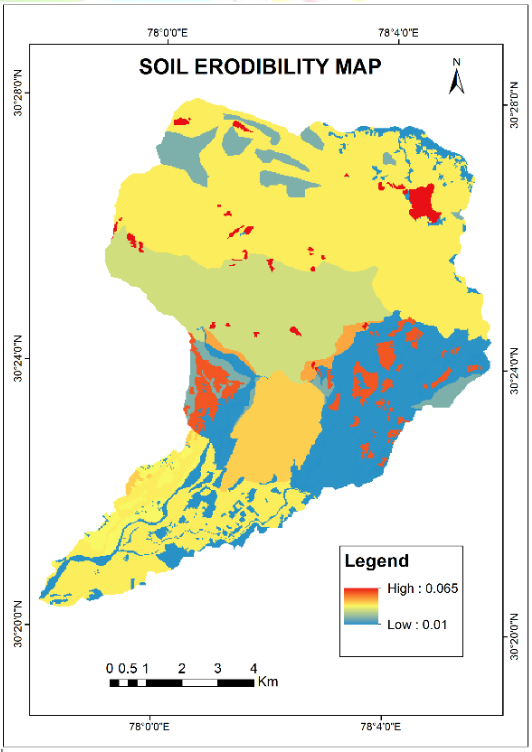
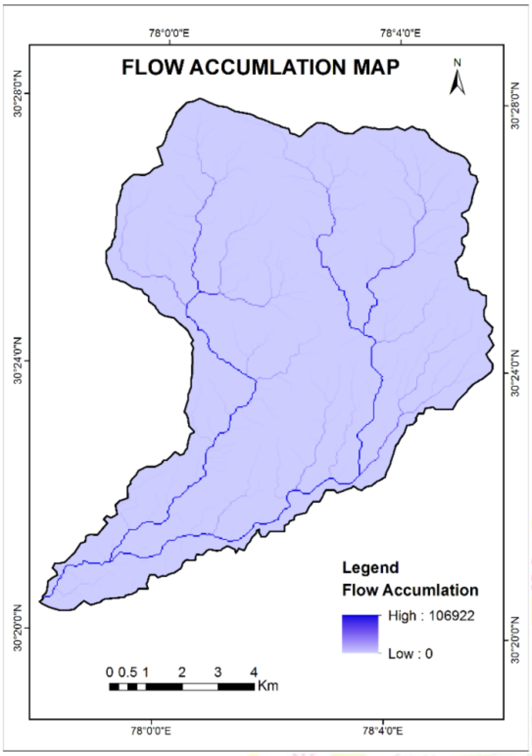


Fig. 9 Soil Erodibility (K)



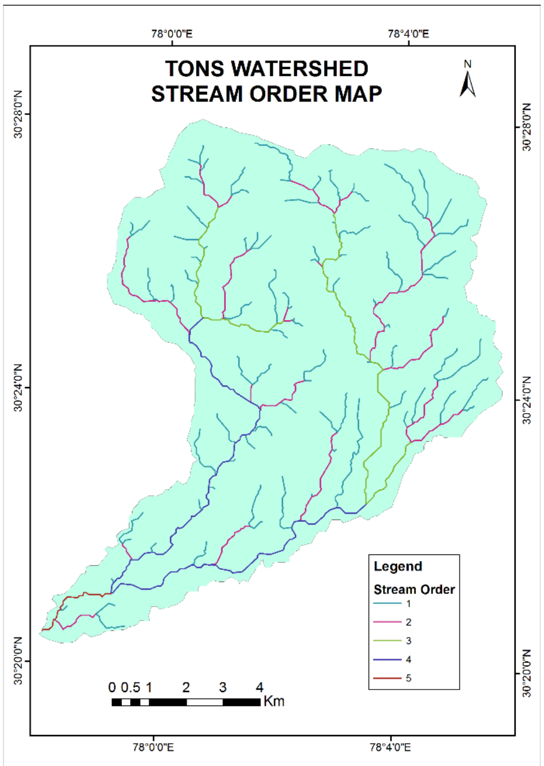
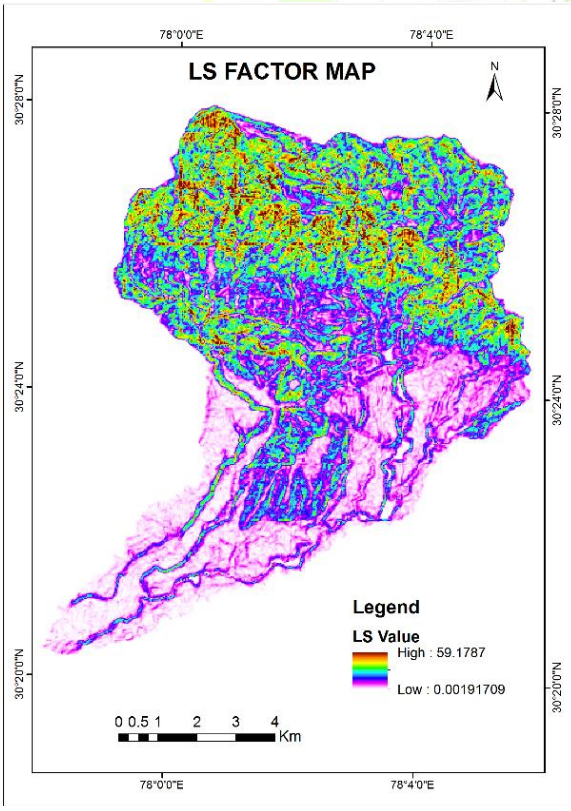


Fig. 10: Flow Accumulation Fig. 11. Stream Order



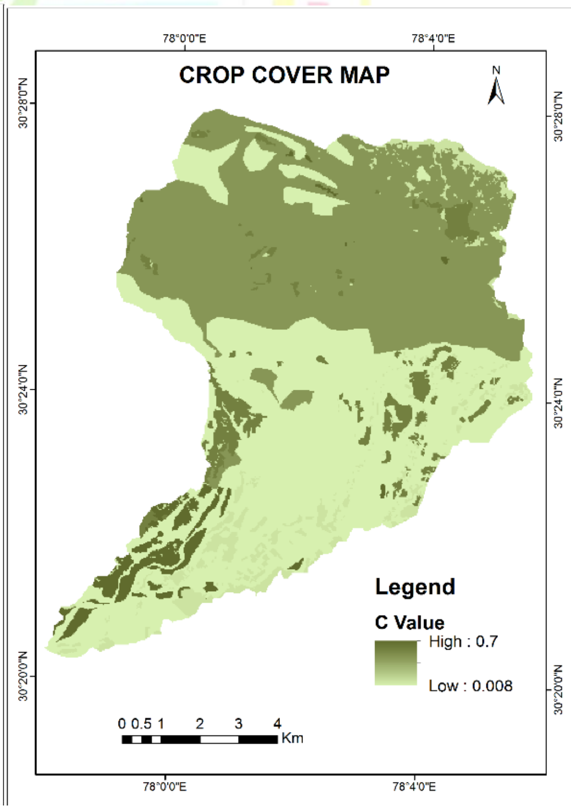
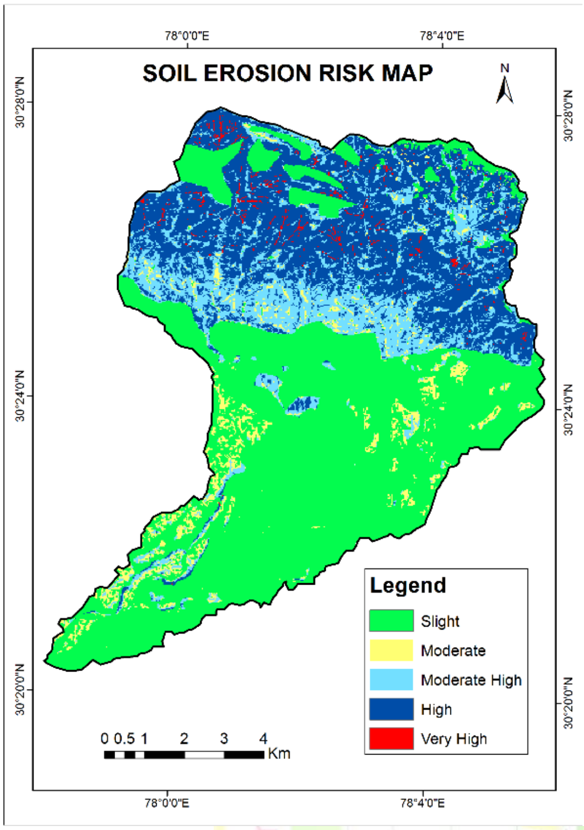


Fig. 12: Topographic (LS) Factor Fig. 13: C Factor



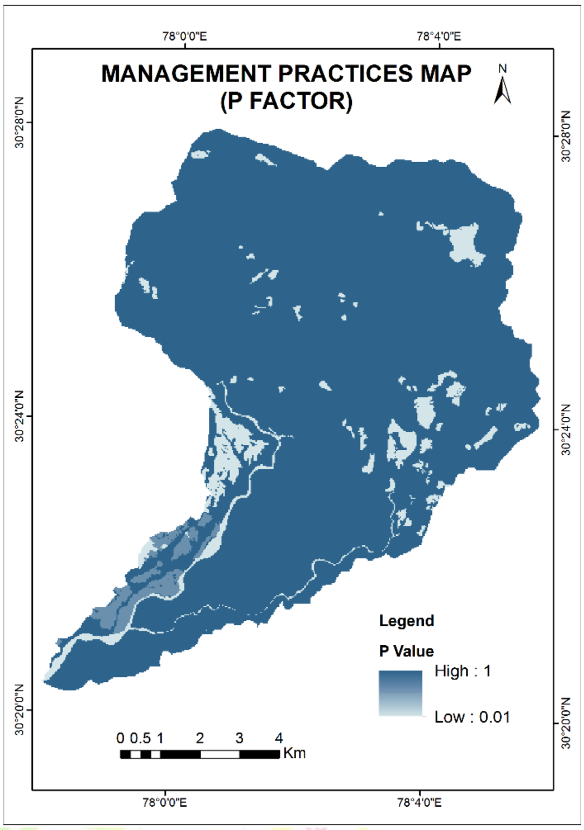


Fig. 14: P Factor **Fig. 15: Soil Erosion Risk**

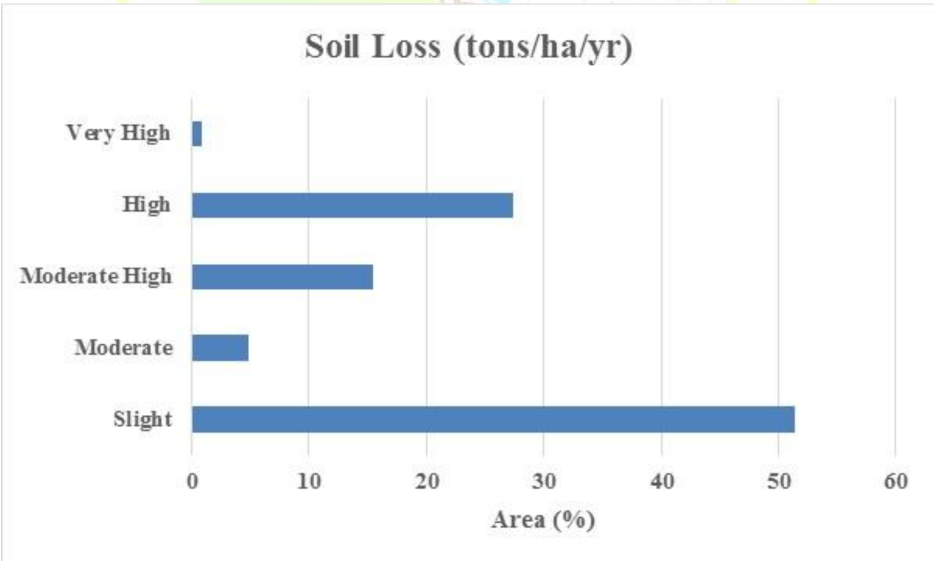


Fig. 17